LEGEND: **DRAFT 06/07/16**
Blue bold text is added from 10 CSR 20-8.020(9)(D).
Green text is added from Iowa.
Brown text is added from Texas Chapter 217-D 2008
Purple text is added from draft 10 CSR 20-8.120 Gravity Sewers.
Red text is added from draft 10 CSR 20-8.130 Pumping Stations.
Underline text is added or altered from the previous stakeholder meeting on March 29, 2016.

Title 10 – DEPARTMENT OF NATURAL RESOURCES
Division 20 – Clean Water Commission
Chapter 8 – Design Guides

10 CSR 20-8.125 Alternative Sewer Systems.

PURPOSE: The following criteria have been prepared as a guide for the design of alternative sewers. This rule is to be used with rules 10 CSR 20-8.110 through 10 CSR 20-8.210 for the planning and design of the complete treatment facility. This rule reflects the minimum requirements of the Missouri Clean Water Commission in regard to adequacy of design, submission of plans, approval of plans, and approval of completed wastewater treatment facilities and collection systems. It is not reasonable or practical to include all aspects of design in these standards. The design engineer should obtain appropriate reference materials which include but are not limited to: copies of all ASTM International and American Water Works Association (AWWA) standards pertaining to sewers and appurtenances, design manuals such as Water Environment Federation's Manuals of Practice, and other sewer design manuals containing principles of accepted engineering practice. Deviation from these minimum requirements will be allowed where sufficient documentation is presented to justify the deviation. It is anticipated that these criteria will be subject to review and revision periodically as additional information and methods appear.

(1) Definitions. Definitions as set forth in the Clean Water Law and 10 CSR 20-2.010 shall apply to those terms when used in this rule, unless the context clearly requires otherwise. Where the terms "shall" and "must" are used, they are to mean a mandatory requirement insofar as approval by the Missouri Department of Natural Resources (department) is concerned, unless justification is presented for deviation from the requirements. Other terms, such as "should," "recommend," "preferred," and the like, indicate the preference of the department for consideration by the design engineer.

(A) Deviations. Deviations from these rules may be approved by the department when engineering justification satisfactory to the department is provided. Justification must substantially demonstrate in writing and through calculations that a variation(s) from the design rules will result in either at least equivalent or improved effectiveness. Deviations are subject to case-by-case review with individual project consideration.

(B) Alternative Sewer Systems. Alternative sewer systems include pressurized sewers carrying raw wastewater from grinder pumps, pressurized or gravity sewers carrying septic tank effluent, and combinations thereof. Although each alternative collection technology uses different motive forces (pressure, gravity, and vacuum) to move wastewater from its source to its destination, there are many commonalities. All use lightweight plastic pipe buried at shallow depths, with fewer joints due to increased pipe lengths than typical gravity sewers. Alternative sewer systems are generally lower in capital costs than conventional gravity sewers.

(C) Building Lateral. A building lateral is a pipe or conduit that conveys wastewater from only one (1) building to a point where it is joined to an alternative sewer system unit (i.e., grinder pump station and septic tank). Maintenance and ownership of the building lateral is generally the responsibility of the property owner.

(D) Collection System. A collection system is a network of pipes or similar conduits and all other structures, devices and appurtenances excluding building laterals for collecting and conveying wastewater to treatment or other disposal facilities. Maintenance and ownership of the collection system is the responsibility of one (1) of the continuing authorities listed in 10 CSR 20-6.010(3)(B).

(E) Equivalent Dwelling Unit (EDU). An equivalent dwelling unit is a system that produces raw wastewater equivalent to a typical single family residence in volume and strength.

(F) Pressure Sewers. Pressure sewers consists of a small diameter pipeline, generally following the profile of the ground, which receives macerated wastewater for conveyance from two (2) or more grinder pump stations.

(G) Septic Tank Effluent Pumped (STEP) Sewers. STEP sewers consist of small diameter pipeline, generally following the profile of the ground which receives effluent wastewater for conveyance from two (2) or more septic tanks with pumps.

(H) Septic Tank Effluent Gravity (STEG) Sewers. STEG sewers consist of small diameter pipeline which flows exclusively under the influence of gravity and receives effluent wastewater for conveyance from two (2) or more septic tanks.

(I) Service Line. A service line is a pipe or conduit that conveys wastewater from one (1) alternative sewer system unit (i.e., grinder pump station and septic tank) to a point where it is joined to a sanitary sewer system which is operated and maintained by one (1) of the continuing authorities listed in 10 CSR 20-6.010(3)(B).

(J) Sewer. A pipe or conduit that conveys wastewater or stormwater.

(K) Sewer Main. Sewer mains are used to convey wastewater from one (1) or more service lines to conventional gravity sewers, treatment, or other disposal facilities. A sewer main is considered part of a sanitary sewer system that is operated and maintained by one (1) of the continuing authorities listed in 10 CSR 20-6.010(3)(B).

(L) Vacuum Sewer. Vacuum sewers consist of small diameter pipeline, generally following the profile of the ground. It uses the differential pressure between atmospheric pressure and a partial vacuum maintained in the piping and vacuum station collection vessel.

(2) Applicability. This rule shall apply to all alternative sewer systems.

(3) Approval of Sewers. The department will approve plans for new collection systems, extensions to new areas, or replacement sanitary sewers only when designed upon the separate basis, where rain water from roofs, streets, and other areas and groundwater from foundation drains are excluded.

(4) Design Capacity and Design Flow. Sewer capacity and flow shall be in accordance with 10 CSR 20-8.120(4).

(5) Supplement to the Engineering Report. Alternative sewer systems are not to be used in lieu of conventional gravity sewers, but may be acceptable when it can be shown in the engineering report that it is not feasible to provide conventional gravity sewers. Use of alternative sewer systems should only be considered when justified by unusual terrain or geological formations, low population density, difficult construction, or other circumstances where alternative sewer systems would offer a clear advantage over conventional gravity sewers. Refer to 10 CSR 20-8.110(4)(B) for more information.

(6) General.

(A) Continuing Authority. When alternative sewer systems are utilized, the continuing authority shall be responsible for the operation and maintenance and modernization of the collection system. Publicly owned treatment works are exempt from continuing authority responsibilities of alternative sewer individual units (i.e., grinder pump stations, septic tanks, and septic tank pumps). See 10 CSR 20-6.010(3) for acceptable continuing authorities.

(B) Flooding. Wastewater pumping station structures and electrical and mechanical equipment shall be protected from physical damage by not less than one foot (1') above the one hundred (100)-year flood elevation or one foot (1') above the highest historical flood elevation, whichever is higher. Wastewater pumping station structures should remain fully operational and accessible during the twenty-five (25)-year flood.

(C) Accessibility. Pumping station structures and septic tanks shall be readily accessible by maintenance vehicles during all weather conditions. Pumping station structures and septic tanks should be located off the traffic way of streets and alleys.

(D) Security. The design of an alternative sewer system, including all mechanical and electrical equipment, must restrict access by an unauthorized person, discourage vandalism, and prohibit the entrance of animals. It is recommended that electrical control panels and access hatches with locks be provided. Bolt down lids are recommended for septic tanks. Also refer to 10 CSR 20-8.140(9)(A)1.

(E) Buoyancy. Where high groundwater conditions are anticipated, buoyancy of the piping and wastewater structures shall be considered and, if necessary, adequate provisions shall be made for protection.

(F) Identification. Where sewers are constructed of a material that might cause the sewer to be confused with potable water mains, the sewer shall be appropriately identified.

(G) Locator Wire. Locator wire shall be installed and shall comply with 10 CSR 20-8.120(11).

(H) Sewers in Relation to Streams. The location and construction of sewers in relation to streams shall be in accordance with 10 CSR 20-8.120(8).

(I) Aerial Crossings. Aerial crossings shall comply with 10 CSR 20-8.120(9).

(J) Potable Water Sources. The distance between wastewater pumping station structures and all potable water sources should be one hundred feet (100') and shall be at least fifty feet (50') in accordance with 10 CSR 23-3.010(2)(A)5.

(K) Protection of Water Supplies. The separation and crossings of water supplies shall be in accordance with 10 CSR 20-8.120(10).

(L) Erosion Control During Construction. Effective site erosion control shall be provided during construction. Erosion control activities shall obtain a stormwater permit for land disturbance activities that meet the requirements of the land disturbance permit, in accordance with 10 CSR 20-6.200.

(M) Grading and Landscaping. Upon completion of construction, the ground should be graded and either sodded or seeded. Where possible, steep slopes should be avoided to prevent erosion and to minimize slips, trip, and falls. Surface water shall not be permitted to drain into the collection system.

(N) Odor Control. Provisions for odor control shall be considered in the design of alternative sewer systems.

(7) Pressure Sewers.

(A) Sewer Design. Pressure sewer systems shall be laid out in a dendritic pattern (e.g. branched tree configuration). The purpose of the branched layout is to have a predictable minimum self-cleaning velocity in the sewer mains. Also, a section of the piping system may be shut down for repairs without interrupting flow from all upstream inputs.

1. Velocity. The velocity shall be based on the most probable number of pumping units expected to operate simultaneously or on some other acceptable method of computing the peak pumpage rate.

A. A cleansing velocity of at least two feet per second (2 ft/s) shall be achieved at least once and preferably several times per day.

B. The maximum velocity in any portion of the system shall be eight feet per second (8 ft/s) without velocity protection and thirteen feet per second (13 ft/s) with velocity protection.

2. Minimum size. The minimum diameter sewer main pipe shall not be less than one and a half inches (1.5").

3. Pipe sizing. The following are the recommended pipe sizes based on the following Equation 125-1 and Table 125-1, included herein:

$$Q = 0.5N + 20$$

Equation 125-1. Design flow based on the number of equivalent dwelling units (EDUs).

where

Q = design flow (gpm)

N = the number of EDUs

Table 125-1. Approximate Sewer Main Sizes to Serve the Number of EDUs

Nominal Pipe Size (in)	EDUs
1.5	3

2	6
3	60
4	120
6	240
8	560

4. Cover. All sewers shall be covered with at least thirty-six inches (36") of soil, other insulation, or material to prevent freezing and to protect them from superimposed loads. Insulation shall be provided for sewers that cannot be placed at a depth sufficient to prevent freezing.

5. Materials. Any generally accepted material for sewers will be given consideration, but the material selected shall be adapted to local conditions, such as character of industrial wastes, possibility of septicity, soil characteristics, exceptionally heavy external loadings, abrasion, corrosion, or similar problems.

A. All sewer pipe and joint materials shall conform to the appropriate ASTM specifications.

B. Suitable couplings complying with ASTM specifications shall be used for joining dissimilar materials.

C. All sewers shall be designed to prevent damage from superimposed live, dead, and frost-induced loads. Proper allowance for loads on the sewer shall be made because of soil and potential groundwater conditions, as well as the width and depth of the trench. Where necessary, special bedding, haunching, initial backfill, concrete cradle, or other special construction shall be used to withstand anticipated superimposed loading or loss of trench wall stability.

D. For new pipe or joint materials for which ASTM standards have not been established, the design engineer shall provide complete material and installation specifications developed on the basis of criteria adequately documented and certified in writing by the manufacturer to be satisfactory for the specific detailed plans submitted for approval by the department.

6. Installation. Refer to 10 CSR 20-8.120(5)(H)1. through 10 CSR 20-8.120(5)(H)4.

7. Termination. The sewer main shall enter the receiving manhole with a smooth flow transition to the gravity sewer system at a point not more than one foot (1') above the flow line. The design shall minimize turbulence and scouring at the point of discharge. Corrosion protection for the receiving manhole shall be provided in accordance with 10 CSR 20-8.120(6)(H).

8. Design friction losses.

A. Friction coefficient. Friction losses through the sewers shall be based on the Hazen-Williams formula or other acceptable method (e.g. the Darcy-Weisbach equation). When the Hazen-Williams formula is used, the value for “C” shall be one hundred (100) for unlined iron or steel pipe for design. For other smooth pipe materials such as polyvinyl chloride, polyethylene, lined ductile iron, etc., a higher “C” value, not to exceed one hundred thirty (130), may be allowed for design.

B. Maximum power requirements. When initially installed, the sewers will have a significantly higher "C" factor. The effect of the higher "C" factor shall be considered when calculating maximum power requirements and duty cycle time to prevent damage to the motor. The effects of higher discharge rates on selected pumps and downstream facilities shall also be considered.

9. Hydrostatic pressure test. Hydrostatic testing shall, as a minimum, conform to the test procedure described in AWWA C600 for ductile iron pipe and AWWA C605 for plastic pipe. For other materials, test procedures shall be approved by the department.

10. Air testing. The air test shall, as a minimum, conform to the test procedure described in ASTM F1417 for plastic, composite, and ductile iron pipe. For other materials, test procedures shall be approved by the department.

11. Corrosion. Where corrosive conditions due to septicity or other causes are anticipated, corrosion protection of the interior pipe shall be provided.

12. Cleaning. Consideration should be given to providing a suitable method of cleaning the sewer main whenever the velocity in the sewer main may be less than two feet per second (2 ft/s) before ultimate development is reached.

(B) Sewer Appurtenances. All appurtenances shall be compatible with the piping system used and shall be full bore with smooth interior surfaces to eliminate obstruction and keep friction loss to a minimum.

1. Isolation valves. Isolation valves are necessary for isolating sections of lines during line breaks or other emergencies.

A. Isolation valves must be—

(I) Resilient seated gate valve or ball valve with a position indicator;

(II) Constructed from corrosion resistant materials; and

(III) Enclosed in a watertight and lockable valve box.

B. Isolation valves shall be installed—

(I) On the upstream side of major pipe intersections;

(II) On both sides of stream, bridge, and railroad crossings, and unstable soil; and

(III) On the terminal end of the system to facilitate future extensions.

C. The weight of the valve shall not be carried by the pipe. Valves shall be provided with proper support, such as crushed stone, concrete pads, or a well compacted trench bottom.

2. Cleanouts. Accumulation of grease and solids will reduce the pressure sewer system capacity by increasing friction losses. Access to pipeline cleaning is provided by cleanouts.

A. Cleanouts should be installed—

(I) At the end of each line;

(II) At changes in pipe size; and

(III) At pipe intersections.

B. A cleanout must be enclosed in a watertight valve box with a locking cap.

C. Cleanouts shall be provided with proper support, such as crushed stone, concrete pads, or a well compacted trench bottom.

3. Air and Vacuum Relief Valve.

A. Air relief valves shall be placed at high points in pressure sewers to prevent air locking.

B. Vacuum relief valves may be necessary to relieve negative pressures on pressure sewers. The pressure sewer configuration and head conditions should be evaluated as to the need for and placement of vacuum relief valves.

C. An air or vacuum relief valve should have an isolation valve between the air relief valve and the pressure sewer.

D. An air or vacuum relief valve must be constructed from corrosion resistant materials.

E. An air or vacuum relief valve must be inside a vault that has an inside diameter at least thirty inches (30") in diameter with an access opening of twenty-two inches (22") in diameter at a minimum. The vault should have provisions for air displacement to the atmosphere, such as an inverted and screened "j" tube or other means.

F. A pressure sewer should have valves spaced at no more than one thousand five hundred foot (1,500') intervals to facilitate initial testing and subsequent maintenance and repairs.

G. The weight of the valve shall not be carried by the pipe. Valves shall be provided with proper support, such as crushed stone, concrete pads, or a well compacted trench bottom.

4. Anchoring. Pressure sewers shall be sufficiently anchored within the pumping stations and throughout the line length. The number of bends shall be as few as possible. Thrust blocks, restrained joints, and/or tie rods shall be provided where restraint is needed.

5. Pressure monitoring stations. Pressure monitoring stations are recommended to identify areas where air-induced headloss may be occurring. When utilized, pressure monitoring stations shall consist of an access vault to the collection piping, including a threaded tap for a pressure gauge.

(C) Service Line Connection.

1. Service connections to the pressure sewer main shall be watertight and shall not protrude into the sewer main.

2. If a saddle-type connection is used, it shall be a device designed to join with the types of pipe which are to be connected.

3. All materials used to make service connections shall be compatible with each other and with the pipe materials to be joined and shall be corrosion proof.

4. A check valve and isolation valve shall be installed on each service line. Refer to paragraph (7)(B)1. of this rule for more information.

5. The minimum diameter service line pipe shall not be less than one and one quarter inches (1.25").

(D) Grinder Pump Stations.

1. Type. Both centrifugal pumps and progressing cavity semi-positive displacement pumps may be used in pressure sewer systems. The centrifugal pump, a pump having a

maximum head at no flow, may be considered for its ability to compensate with reduced or zero delivery against excessive high pressures and the ability to deliver at a high rate during low flow situations in the collection system, thus enhancing scouring during low flow periods. The progressing cavity semi-positive displacement pump may be considered for its relatively constant rate of delivery in situations in which this feature is considered necessary. The semi-positive displacement pump has no significant increases in delivery against low-flow system conditions to enhance scour during minimum flow times.

2. Number of pumps.

A. Simplex grinder pump station. A simplex grinder pump stations shall not serve multiple EDUs. Grinder pump stations owned, operated, and maintained by individual homeowners must serve only a single EDU. Simplex grinder pump stations should not be installed at commercial facilities.

B. Multiple unit grinder pump station. Grinder pump stations serving all other service connections (i.e. multiple EDUs, duplexes, apartment complexes, commercial facilities, etc.) shall provide at least two (2) grinder pumps. Where only two (2) units are provided, they shall be of the same size. Units shall have capacity such that, with any unit out-of-service, the remaining units will have capacity to handle the design peak hourly flow. All multiple unit grinder pump stations must be owned, operated, and maintained by an approved continuing authority. See subsection (6)(A) of this rule.

3. Location. A grinder pump station shall be located outdoors and in sight of the structure it is serving with consideration given to future maintenance accessibility.

4. Construction materials.

A. Grinder pump vaults are typically constructed from fiberglass reinforced polyester, high density polyethylene, steel, or concrete. A fiberglass reinforced polyester pump vault shall have a maximum diameter of four feet (4').

B. All pipes and appurtenances within a grinder pump station must be corrosion resistant. For metal components, austenitic stainless steel of type 316 or 304 shall be provided at a minimum. Nylon is degraded by hydrogen sulfide and is not acceptable.

C. Contact between dissimilar metals should be avoided or other provisions made to minimize galvanic action.

5. Grinder pump vaults shall be watertight.

6. Access. A minimum access diameter of twenty-four inches (24") shall be provided for all grinder pump vaults. A minimum access diameter of forty-eight inches (48") is recommended for duplex grinder pump vaults.

7. Vault cover. Bolt-down cover assemblies or locked covers shall be provided. The use of high density polyethylene vault covers is discouraged.

8. Ventilation. All grinder pump vaults shall have provisions for air displacement to the atmosphere, such as an inverted and screened “j” tube or other means.

9. Storage volume. A grinder pump vault must have a storage volume of at least seventy (70) gallons.

10. Pump removal. Grinder pumps shall be readily removable and replaceable without personnel entering or dewatering the grinder pump station or disconnecting any piping in the grinder pump vault.

11. Valves. The following valves must be provided in the grinder pump vaults:
    A. A shutoff valve accessible from the ground surface;
    B. A check valve to prevent backflow; and
    C. An anti-siphon valve, if siphoning could occur.

12. Grinder pump construction. Grinder pumps shall be designed specifically for raw wastewater use, including totally submerged operation during a portion of each pumping cycle, and shall meet the requirements of the NEC for such units.

13. Pump openings. The grinder unit must be capable of reducing any material which enters the grinder unit to a size that the materials will pass through the pump unit and pressure sewer system without plugging or clogging. No screens or other devices requiring regular maintenance may be used to keep trash or stringy material out of the grinder pump or sewer main.

14. Controls. Water level control sensing devices should be located to prevent undue affects from turbulent flows entering the grinder pump station or by the turbulent suction of the pumps. Water level controls must be accessible without entering the grinder pump station. Provision shall be made to automatically alternate the pumps in use for duplex grinder pump stations.

15. Electrical equipment. Electrical equipment shall be in accordance with 10 CSR 20-8.130(6)(D). Pump station control panels should be provided with a portable generator receptacle.

16. Flow measurement. All grinder pump stations shall be equipped with elapsed time meters, at a minimum, provided sufficient equipment is provided to measure the duration of individual and simultaneous pump operation.

17. Alarm systems. Alarm systems with a backup power source shall be provided for all grinder pump stations. The alarm shall be activated in cases of power failure, high water levels, pump failure, or any other cause of grinder pump station malfunction. Audio-visual alarm systems shall be provided at a minimum.
    A. When the continuing authority operates and maintains the grinder pump stations, a sign shall be posted at each grinder pump station in a clearly visible location, listing a telephone number, which is manned twenty-four (24) hours a day, to be called if the alarm is seen or heard.

18. Emergency operations. When the continuing authority operates and maintains the grinder pump stations, provisions must be made for periods of mechanical or power failure. Acceptable alternatives are as follows:
    A. Provide additional storage capacity where power outages occur frequently (twenty-four (24)-hour storage capacity is recommended);
    B. Provide a portable generator to connect to each grinder pump station for a short term during an extended outage; or

C. Provide a portable pump to connect to each grinder pump station by means of quick coupling portable pump connections on the discharge.

19. Spare parts. When the continuing authority operates and maintains the grinder pump stations, an inventory of five percent (5%) of the number of grinder pumps in operation for each model installed must be provided with a minimum of two (2) grinder pumps. All working parts of the grinder pump stations should be on hand in sufficient quantity.

(8) Septic Tank Effluent Pumped (STEP) Sewers.

(A) Sewer Design. Refer to subsection (7)(A) of this rule.

(B) Sewer Appurtenances. Refer to subsection (7)(B) of this rule.

(C) Service Line Connection. Refer to subsection (7)(C) of this rule.

(D) Septic Tank Design.

1. A single septic tank shall serve no more than one (1) EDU.

2. Capacity. A septic tank must have a capacity of at least one thousand (1,000) gallons. Twenty percent (20%) of the septic tank volume is usually provided for freeboard and ventilation.

3. Construction materials.

A. Septic tanks are typically constructed from fiberglass reinforced polyester, high density polyethylene, or concrete.

B. All pipes and appurtenances within a septic tank must be corrosion resistant. For metal components, austenitic stainless steel of type 316 or 304 shall be provided at a minimum. Nylon is degraded by hydrogen sulfide and is not acceptable.

C. Contact between dissimilar metals should be avoided or other provisions made to minimize galvanic action.

4. Septic tanks shall be watertight.

5. Access. A minimum access diameter of twenty-four inches (24") shall be provided to service the tank and outlet screen. Bolt-down cover assemblies or locked covers shall be provided. The use of high density polyethylene access covers is discouraged.

6. Inlet and outlet tees. Inlet and outlet tees shall be provided to maximize removal and retention of solids within the septic tank.

7. Ventilation. Septic tanks must be ventilated. Typical ventilation is through the plumbing stack of the structure it is serving.

8. Outlet screen. The septic tank outlet shall have an effluent screen to reduce large solids from entering the sewers.

9. Location. Septic tanks shall be buried with access risers at or above grade and in sight of the structure it is serving with consideration given to future maintenance and removal of accumulated solids accessibility.

(E) Existing Septic Tanks. When existing on-site septic tanks are proposed for reuse in an alternative sewer system, they must be inspected and verified watertight prior to acceptance. Existing septic tanks may be a source of infiltration and inflow without proper inspection. Acceptable existing septic tanks proposed for reuse must conform, at a minimum, to paragraphs (8)(D)1. through (8)(D)8. of this rule.

(F) Pump Vault Design. The pump vault shall be located within the septic tank at the outlet or located outside the septic tank in a separate pump vault. The pump shall be protected by an outlet screen.

1. Simplex submersible pump shall be provided. The pump is typically a low-head and low-capacity design.
2. Construction materials. Pump vaults are typically constructed from fiberglass reinforced polyester or high density polyethylene.
3. Access. A minimum access diameter of twenty-four inches (24") shall be provided for simplex pump vaults. Duplex pump vaults must have a minimum access diameter of forty-eight inches (48").
4. Vault cover. Bolt-down cover assemblies or locked covers shall be provided.
5. Pump removal. Pumps shall be readily removable and replaceable without personnel entering or dewatering the septic tank or disconnecting any piping in the pump vault.
6. Valves. The following valves must be provided in the pump vaults:
   A. A shutoff valve accessible from the ground surface;
   B. A check valve to prevent backflow; and
   C. An anti-siphon valve, if siphoning could occur.
7. Pump construction. Pumps shall be designed specifically for raw wastewater use, including totally submerged operation during a portion of each pumping cycle, and shall meet the requirements of the NEC for such units.
8. Controls. Water level controls sensing devices should be located to prevent undue affects from turbulent flows entering the pumps or by the turbulent suction of the pumps. Water level controls must be accessible without entering the pump vault. Provision shall be made to automatically alternate the pumps in use for duplex pump vaults.
9. Electrical equipment. Electrical equipment shall be in accordance with 10 CSR 20-8.130(6)(D).
10. Flow measurement. All pump vaults shall be equipped with elapsed time meters, at a minimum, provided sufficient equipment is provided to measure the duration of individual and simultaneous pump operation.
11. Alarm systems. Alarm systems with a backup power source shall be provided for all pump vaults. The alarm shall be activated in cases of power failure, high water levels, pump failure, or any other cause of malfunction. Audio-visual alarm systems shall be provided at a minimum.
   A. When the continuing authority operates and maintains the septic tank and pump, a sign shall be posted at each pump vault in a clearly visible location, listing a telephone number, which is manned twenty-four (24) hours a day, to be called if the alarm is seen or heard.
12. Emergency operations. Provisions must be made for periods of mechanical or power failure.
13. Spare parts. When the continuing authority operates and maintains the septic tank and pump, an inventory of five percent (5%) of the number of septic tank pumps in operation

for each model installed must be provided with a minimum of two (2) pumps. All working parts of the pump vault should be on hand in sufficient quantity.

(9) Septic Tank Effluent Gravity (STEG) Sewers.

(A) Sewer Design. Sewer mains may be laid with a variable grade, as long as a positive head exists to drive the wastewater toward a terminal location, which allows the sewer to follow the natural topography of the area.

1. Velocity. The maximum velocity in any portion of the system shall be thirteen feet per second (13 ft/s) with velocity protection.

2. Minimum size. The minimum diameter sewer main pipe shall not be less than four inches (4").

3. Cover. All sewers shall be covered with at least thirty-six inches (36") of soil, other insulation, or material to prevent freezing and to protect them from superimposed loads. Insulation shall be provided for sewers that cannot be placed at a depth sufficient to prevent freezing.

4. Materials. Any generally accepted material for sewers will be given consideration, but the material selected shall be adapted to local conditions, such as character of industrial wastes, possibility of septicity, soil characteristics, exceptionally heavy external loadings, abrasion, corrosion, or similar problems.

A. All sewer pipe and joint materials shall conform to the appropriate ASTM specifications.

B. Suitable couplings complying with ASTM specifications shall be used for joining dissimilar materials.

C. All sewers shall be designed to prevent damage from superimposed live, dead, and frost-induced loads. Proper allowance for loads on the sewer shall be made because of soil and potential groundwater conditions, as well as the width and depth of the trench. Where necessary, special bedding, haunching, initial backfill, concrete cradle, or other special construction shall be used to withstand anticipated superimposed loading or loss of trench wall stability.

D. For new pipe or joint materials for which ASTM standards have not been established, the design engineer shall provide complete material and installation specifications developed on the basis of criteria adequately documented and certified in writing by the manufacturer to be satisfactory for the specific detailed plans submitted for approval by the department.

5. Installation. Refer to 10 CSR 20-8.120(5)(H)1. through 10 CSR 20-8.120(5)(H)4.

6. Termination. The sewer main shall enter the receiving manhole with a smooth flow transition to the gravity sewer system at a point not more than one foot (1') above the flow line. The design shall minimize turbulence and scouring at the point of discharge. Corrosion protection for the receiving manhole shall be provided in accordance with 10 CSR 20-8.120(6)(H).

7. Design friction losses.

A. Friction coefficient. Friction losses through the sewers shall be based on the Hazen-Williams formula or other acceptable method (e.g. the Darcy-Weisbach equation). When the Hazen-Williams formula is used, the value for "C" shall not exceed one hundred (100).

B. Maximum power requirements. When initially installed, the sewers will have a significantly higher "C" factor. The effect of the higher "C" factor shall be considered when calculating maximum power requirements and duty cycle time to prevent damage to the motor. The effects of higher discharge rates on selected pumps and downstream facilities shall also be considered.

8. Curvilinear alignment. Curvilinear horizontal and vertical alignment may be considered provided compression joints are specified and ASTM or specific pipe manufacturer's maximum allowable pipe joint deflection limits are not exceeded.

9. Leakage tests. Leakage tests shall be specified. This may include appropriate water or low pressure air testing. The testing method(s) specified shall take into consideration the range in groundwater elevations during the testing and those anticipated during the design life of the sewer.

A. Water (hydrostatic) test. The leakage exfiltration or infiltration shall not exceed one hundred (100) gallons per inch of pipe diameter per mile per day for any section between manholes of the system. An exfiltration or infiltration test shall be performed with a minimum positive head of two feet (2').

B. Air test. The air test shall, as a minimum, conform to the test procedure described in ASTM F1417 for plastic, composite, and ductile iron pipe. For other materials, test procedures shall be approved by the department.

10. Corrosion. Where corrosive conditions due to septicity or other causes are anticipated, corrosion protection of the interior pipe shall be provided.

11. Cleaning. Consideration should be given to providing a suitable method of cleaning the sewer main whenever the velocity in the sewer main may be less than two feet per second (2 ft/s) before ultimate development is reached.

(B) Sewer Appurtenances. Refer to subsection (7)(B) of this rule. When manholes are utilized at major junctions of sewer mains, refer to 10 CSR 20-8.120(6).

(C) Service Line Connection. Refer to paragraphs (7)(C)1. through (7)(C)2. of this rule.

1. The diameter of service line pipe shall not be less than four inches (4").

(D) Septic Tank Design. Refer to subsections (8)(D) through (8)(E) of this rule.

(10) Combination of Sewers.

(A) Gravity Sewers. The combination of gravity sewers and any alternative sewer system is acceptable.

(B) STEP and STEG. The combination of STEP and STEG sewer system is common and acceptable since both designs use septic tanks and effluent sewers.

(C) Pressure Sewers. STEP and STEG sewers systems discharging to a downstream pressure sewer system is acceptable. However, a pressure sewer system discharging to a downstream

STEP and STEG sewer system shall not be permitted, since effluent sewers are not designed to carry settleable solids and grease.

(11) Vacuum Sewers. Vacuum sewers shall be evaluated on a case-by-case basis. Design standards, operating data, and experience for this system are not well established in Missouri.

(12) Supplement to Summary of Design. The summary of design shall contain the following information in addition to that required in 10 CSR 20-8.110(5).

(A) Pressure Sewers. The following must be included for pressure sewer systems:

1. Hydraulic loadings including the design average flow and the design peak hourly flow;
2. Pipe size, material, type or class, and length;
3. Velocity calculations for each pipe segment;
4. The elevation of the hydraulic grade-line and ground elevation at peak hourly flow for each pipe segment;
5. Calculated design friction losses;
6. Number and location of stream crossings;
7. Number of isolation valves, cleanouts, and air and vacuum relief valves;
8. Number of simplex and duplex grinder pump stations;
9. Calculations showing that grinder pump stations are protected against buoyancy forces;
10. Static head;
11. Total dynamic head;
12. Selected pump manufacturer's information including the model number, type, horsepower, speed in revolutions per minute, voltage, and phase;
13. Pump capacity in gallons per minute;
14. Performance curves for each pump with the system curve plotted and the pump's operating point marked.
15. Cycle times based on design average flow and design peak hourly flow; and
16. Method of emergency operations.

(B) STEP Sewers.

1. Hydraulic loadings including the design average flow and the design peak hourly flow;
2. Pipe size, material, type or class, and length;
3. Velocity calculations for each pipe segment;
4. The elevation of the hydraulic grade-line and ground elevation at peak hourly flow for each pipe segment;
5. Calculated design friction losses;
6. Number and location of stream crossings;
7. Number of isolation valves, cleanouts, and air and vacuum relief valves;
8. Number of septic tanks;
9. Calculations showing that septic tanks are protected against buoyancy forces;
10. Static head;
11. Total dynamic head;

12. Selected pump manufacturer's information including the model number, type, horsepower, speed in revolutions per minute, voltage, and phase;
13. Pump capacity in gallons per minute;
14. Performance curves for each pump with the system curve plotted and the pump's operating point marked.
15. Cycle times based on design average flow and design peak hourly flow; and
16. Method of emergency operations.

(C) STEG Sewers. Refer to paragraphs (12)(B)1. through (12)(B)9 of this rule.